Total Maximum Daily Loads (TMDLs)

Plum Run Watershed
Washington County

Pennsylvania Department of Environmental Protection

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Summary of the Plum Run TMDLs

1. These TMDLs were developed for Plum Run, a tributary to Chartiers Creek in State Water Plan subbasin 20-F (Ohio River), located in Washington County, Pennsylvania. Access to the watershed is available by traveling south from Pittsburgh on Interstate 79. Plum Run flows for approximately 4.22 miles in a southeasterly direction to its confluence with Chartiers Run just south of Houston. Several small streams drain the 4.1 square mile watershed. Protected stream uses in the watershed include aquatic life, water supply, and recreation. The entire basin is currently designated as Warm Water Fishes (WWF) use under §93.9w in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001).

2. TMDLs for the Plum Run watershed were developed to address use impairments caused by siltation and nutrients. The sediment and nutrient TMDLs were derived for the streams listed on the 1996 303(d) list. Plum Run first appeared on Pennsylvania's 303(d) list in 1996, when 2.1 miles of the mainstem were listed as impaired by nutrients and suspended solids emanating from agricultural activities. Sediment and total phosphorus TMDLs have been developed to address suspended solids and nutrient impairments. In order to ensure attainment and maintenance of water quality standards in the Plum Run watershed, mean annual loading of sediment and total phosphorus will need to be limited to 92,127 and 312.2 lbs/yr, respectively.

   The major components of the Plum Run watershed TMDLs are summarized below:

Component	Sediment (lbs/yr)	Total Phosphorus (lbs/yr)
TMDL (Total Maximum Daily Load)	92,127	312.2
WLA (Wasteload Allocation)	0	0
MOS (Margin of Safety)	9,213	31.2
LA (Load Allocation)	82,915	281.0

3. The current mean annual sediment loading to Plum Run is estimated to be 178,420 lbs/yr. A 54 percent reduction in sediment loading is required to meet the TMDL. Mean annual total phosphorus loading is estimated to be 382.0 lbs/yr and will require a 26 percent reduction to meet the TMDL.

4. Load Allocations (LA) for sediment and total phosphorus were made to the following nonpoint sources: croplands, coniferous forest, mixed forest, deciduous forest, low intensity development, high intensity development, quarry, stream banks, groundwater, septic systems, and hay and pasture lands.

5. Since there are no point source discharges of sediment or total phosphorus located in the Plum Run watershed, the TMDLs do not include Waste Load Allocations (WLA).

6. The sediment TMDL includes a nonpoint source load allocation (LA) of 82,915 lbs/yr. Allocations to sources receiving reductions (hay and pasture, and cropland) total 74,195 lbs/yr. Sediment loadings from the remaining nonpoint sources (loads not reduced) were maintained at 8,720 lbs/yr. The total phosphorus TMDL includes a nonpoint source LA of 281 lbs/yr. Allocations to sources receiving reductions (hay and pasture, and cropland) total 70.8 lbs/yr. Total phosphorus loadings from all other

nonpoint sources were maintained at 210.2 lbs/yr. Allocations of sediment and total phosphorus to all nonpoint sources in the Plum Run watershed are summarized below:

Load Allocations for Sources of Sediment			
Source	**Current Loading (lbs/yr)**	**Load Allocation (lbs/yr)**	**Percent Reduction**
Hay and Pasture	38,020	25,138	34%
Cropland	131,680	49,056	63%
NPS Loads Not Reduced	8,720	8,720	--
Total	**178,420**	**82,915**	54%

Load Allocations for Sources of Total Phosphorus			
Source	**Current Loading (lbs/yr)**	**Load Allocation (lbs/yr)**	**Percent Reduction**
Hay and Pasture	61.6	32.9	47%
Cropland	110.2	37.9	66%
NPS Loads Not Reduced	210.2	210.2	--
Total	**382.0**	**281.0**	**26%**

7. Ten percent of the Plum Run sediment and total phosphorus TMDLs were set-aside as a margin of safety (MOS). The MOS is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. The MOS for the sediment TMDL and the MOS for the total phosphorus TMDL were set at 9,212.7 lbs/yr and 31.2 lbs/yr, respectively.

8. The continuous simulation model used for developing the Plum Run TMDLs considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions accounts for seasonal variability.

I. Introduction

A. Watershed Description

Plum Run is a tributary to Chartiers Creek in Southwestern Pennsylvania. Plum Run, located in Chartiers Township and Houston Borough, is part of the Upper Chartiers Watershed. Plum Run enters Chartiers Run, which meets Chartiers Creek approximately 0.25 miles downstream.

Plum Run is part of State Water Plan subbasin 20-F (Ohio River) and is located just south of Canonsburg in Washington County, Pennsylvania. Access to the watershed is available by traveling south from Pittsburgh on Interstate 79. Figure 1 presents the location of Plum Run watershed within Pennsylvania, and with reference to an unnamed tributary to Big Run, which is the reference watershed for the Plum Rum TMDL (see Section II-D). Plum Run flows for approximately 4.22 miles in a southeasterly direction to its confluence with Chartiers Run just south of Houston. Several small streams drain the 4.1 square mile watershed. Protected stream uses in the watershed include aquatic life, water supply, and recreation. The entire basin is currently designated as Warm Water Fishes (WWF) under §93.9f in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001).

B. Topography & Geology

The Plum Run basin is approximately 2,600 acres (4.1 square miles). Like most of the upper and western reaches of the Chartiers Watershed, the topography is one of mild slopes, wide valleys, and rolling hills. Slopes in the area range from approximately 14 percent to 24 percent. Elevations in the watershed range from approximately 950 to 1,160 feet. The approximately 4.3 miles of the Plum Run main stem drops a mere 210 feet in elevation (< 1 percent average slope).

Plum Run drains portions of the Appalachian Plateaus physiographic province. The Plum Run watershed is located in the north central portion of the Waynesburg Hills Section. This section consists of steep-sloped narrow valleys, with narrow hilltops. The Waynesburg Hills Section is very hilly and has elevations ranging from approximately 850 to 1,650 feet. Horizontal beds consisting of sandstones, shales, and limestones underlie this section.

The primary geologic formation in the Pine Run watershed is Monongahela Group. This group is found along the middle and upper sections of Pine Run. The group consists of primarily of limestone, and also consists of shale, sandstone, and coal. The lower reaches of Pine Run cuts through the Casselman Formation. This formation consists of shale, along with siltstone, sandstone, limestone, and coal. Pine Run does not cut through the Waynesboro Formation or the Washington Formation. These formations are located in the highest elevations of the watershed. These formations primarily consist of sandstone, but also consist of shale, limestone, and coal.

The primary soil association in the watershed is the Gilpin-Dormont-Culleoka, which makes up approximately 94 percent of the watershed. The Dormont-Culleoka-Guernsey soil association makes up approximately 2 percent of the remaining area. Table 1 presents the soil series in the watershed.

Figure 1 - Plum Run Watershed, Washington County

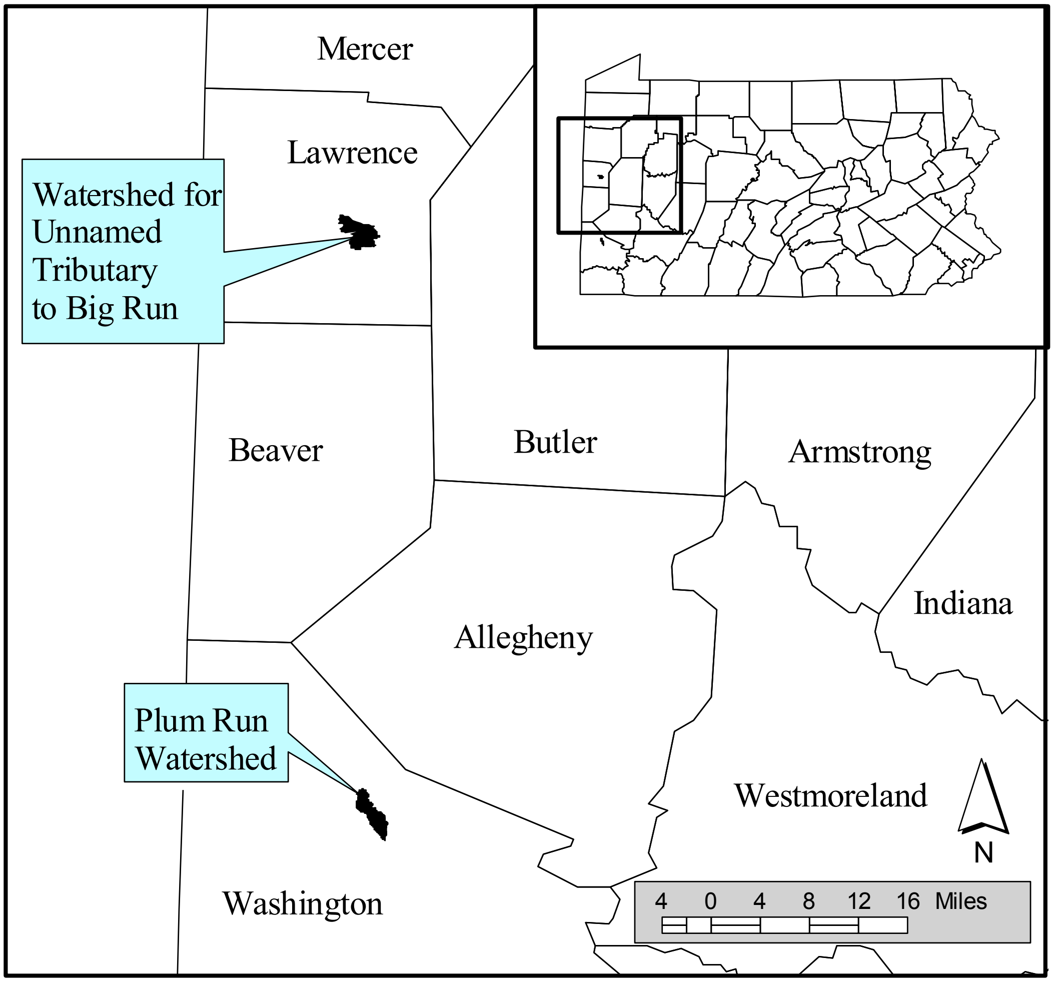


Table 1 - Soil Series Characteristics		
Soil Series	**Drainage Class**	**Parent Material**
Dormont	moderately well drained	shale, siltstone, and limestone
Culleoka	well drained	limestone, sandstone, siltstone, and shale residuum
Guernsey	moderately well drained	clay shale, siltstone, and limestone residuum
Gilpin	well drained	shale and fine-grained sandstone residuum

The dominant hydrologic soil group is C, described by the Natural Resource and Conservation Service as soils with finer textures, which have slow infiltration rates when thoroughly wetted.

C. Land Use

In the past, the land use in the Plum Run watershed was primarily agricultural and mining. More recently, residential areas and mixed forests have replaced the mine lands. The present land use distribution is approximately 45 percent mixed forest, 34 percent pasture/hay, 17 percent cropland, 4 percent low intensity development, 0.2 percent high intensity development, and 0.1 percent quarry. The developed areas are concentrated along the southern reaches of Plum Run.

D. Surface Water Quality

Pennsylvania's 1996 303(d) list identified 2.1 miles of Plum Run as impaired by nutrients and suspended solids emanating from agricultural activities in the basin (Table 2) (Figure 2). The original listing of Plum Run is unknown. The sediment and nutrient TMDLs were derived for the streams listed on the 1996 303(d) list.

As part of the Department's Unassessed Waters, now the Surface Waters Assessment Program, Plum Run was assessed in 1997. The surveys consisted of a habitat assessment, field identification of benthic macroinvertebrates to the family level, and field measurements of the following parameters: pH, temperature, dissolved oxygen, and conductivity. The information collected during these surveys identified use impairments for the entire Plum Run watershed.

Stream surveys conducted in 1997, as part of Pennsylvania's Unassessed Waters Program, listed the Plum Run watershed as impaired (Table 3). The sources and causes of impairment are siltation and turbidity from habitat modifications, nutrients and organic enrichment from some onsite wastewater problems, and in the headwaters, nutrients and siltation from agriculture.

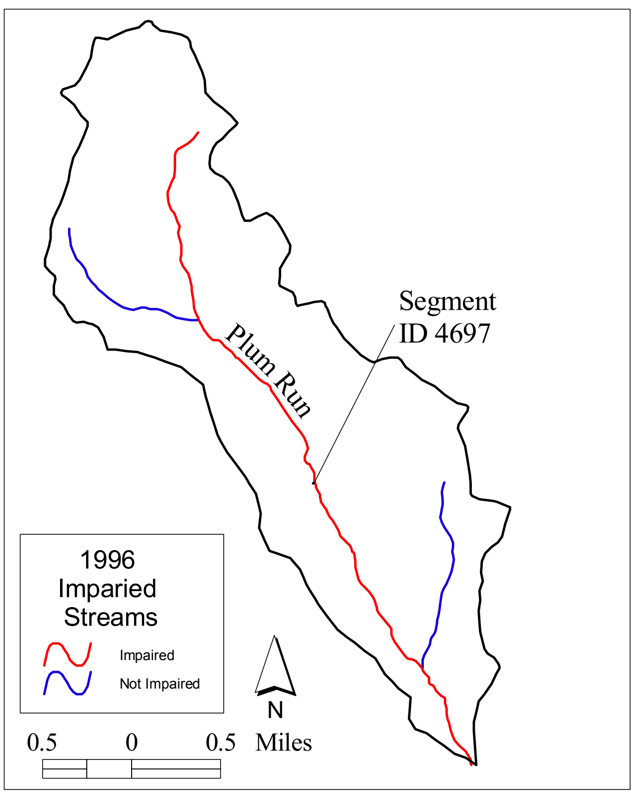
Plum Run continued to have impairments of turbidity and siltation from agriculture (1.0 mile) as well as habitat modifications causing additional siltation (2.1 miles) and onsite wastewater problems with nutrients and organic enrichment (2.1 miles). *Gammarus*, Planaria, and midges were the dominant macroinvertebrates. All habitat scores, except for channel alteration, were low at both stations.

Table 2 - 1996 303(d) Listings for Plum Run Watershed

1996 303(d) LIST					
Stream Name	**Stream Code**	**Segment ID**	**Source**	**Cause**	**Miles**
Plum Run	37044	4697	Agriculture	Nutrients and Suspended Solids	2.1

Table 3 - 1998 303(d) Listings for Plum Run Watershed					
1998 303(d) LIST					
Stream Name	**Segment ID**	**Data Source**	**Source Code**	**Cause Code**	**Miles**
Plum Run	971023-1300-ALF	SWWAP	Habitat Modification	Habitat Alterations and Siltation	1.1
Plum Run	971023-1300-ALF	SWWAP	On-site Wastewater	Organic Enrichment and Nutrients	1.1
Plum Run	971023-1400-ALF	SWWAP	Habitat Modification	Habitat Alterations	1
Plum Run	971023-1400-ALF	SWWAP	Habitat Modification	Siltation and Turbidity	1
Plum Run	971023-1400-ALF	SWWAP	On-site Wastewater	Organic Enrichment	1
Plum Run	971023-1400-ALF	SWWAP	Agriculture	Nutrients and Siltation	1

Figure 2 - Stream Segment on the 1996 303(d) List, Plum Run Watershed



II. Approach to TMDL Development

A. Pollutants & Sources

There are no known point source discharges of nutrients or sediment present in the watershed. Assessments conducted by PA DEP in November 2002 identified agricultural areas in the headwaters of the watershed as possible sources nutrients and sediment. Improperly managed agricultural activities may impact surface water by contributing nutrients and sediment. Improper fertilizer management can contribute nutrients from excessive use of commercial fertilizer or manure, improper application methods or timing, or inadequate BMPs to minimize leaching or runoff. Nutrients cause excessive plant and algae growth. Row-crop production can also increase the sediment load in lakes and rivers. Exposed soil is more susceptible to wind and water erosion.

There are livestock present in the watershed. The PA DEP assumes that the area of the watershed listed as pasture is utilized for pasturing livestock. Manure contains nutrients, when animals are allowed continuous, unrestricted access to streams and lakes, manure ends up in the water and riparian vegetation may be severely damaged. Exposed, compacted soil is more susceptible to erosion and is more difficult to re-vegetate. Manure from livestock operations away from the water’s edge may also cause problems if it is not properly contained and managed. When animals are confined in feeding areas, vegetation is usually limited and manure is concentrated. During storm events this material might find its way to the streams by means of surface runoff.

An increase in impervious surface in a watershed may result in greater frequency of higher velocity runoff events, if proper BMPs are not employed. These increased events result in the modification of the stream channel in an effort to become stable. The most evident repercussion of this stream channel adjustment is the increased erosion on the outside of bends (stream bank erosion) and the subsequent deposition of sediment on the downstream inside of bends.

Wastewater is also a potential source of nutrients. Population within the watershed is estimated to be on the order of 10,000 to 15,000. The watershed is largely on public sewer, but there are approximately about 50 on-site septic systems located within the watershed. Leaks from these systems could contribute to the nutrient load to Plum Run.

B. TMDL Endpoints

In an effort to address nutrient and siltation impairments found in the Plum Run watershed, Total Maximum Daily Loads (TMDLs) were developed for sediment and total phosphorus. The sediment TMDL was developed to address siltation impairments from agricultural sources. The total phosphorus TMDL is intended to address nutrient impairments in the Plum Run watershed identified in Pennsylvania’s 1996 303(d) list. The decision to use phosphorus load reductions to address nutrient impairments was based on an understanding of the relationship between nitrogen (N), phosphorus (P), and organic enrichment in stream systems. Elevated nutrient loads (nitrogen and phosphorus in particular) can lead to increased productivity of plants and other organisms (Novotny and Olem, 1994). In aquatic ecosystems the quantities of trace elements are typically plentiful; however, nitrogen and phosphorus may be in short supply. The nutrient that is in the shortest supply is called the limiting nutrient because its relative quantity affects the rate of production (growth) of aquatic biomass. If the limiting nutrient load to a water body can be reduced, the available pool of nutrients that can be utilized by plants and other organisms will be reduced and, in general, the total biomass can subsequently be decreased as well (Novotny and Olem, 1994). In most efforts to control the eutrophication processes in water bodies, emphasis is placed on the limiting nutrient. This is not always the case, if nitrogen is the limiting nutrient, it still may be more efficient to control phosphorus loads if the nitrogen originates from sources, which are difficult to control like nitrates in ground water.

In most freshwater systems, phosphorus is the limiting nutrient for aquatic growth. In some cases, however, the determination of which nutrient is the most limiting is difficult. For this reason, the ratio of the amount of N to the amount of P is often used to make this determination (Thomann and Mueller, 1987). If the N/P ratio is less than 10, nitrogen is limiting. If the N/P ratio is greater than 10, phosphorus is the limiting nutrient. For Plum Run, phosphorus was the limiting nutrient, since the N/P ratio was determined to be around 43. Controlling the phosphorus loading to Plum Run will limit plant growth, thereby helping to eliminate use impairments currently being caused by excess nutrients.

C. Reference Watershed Approach

The TMDLs for the Plum Run watershed were developed to address excessive sediment and phosphorus loadings to the stream. Neither EPA nor Pennsylvania has developed an instream numeric water quality criteria for sediment or phosphorus. Therefore, a method was developed to implement the narrative criteria. The method employed for these TMDLs is termed the “Reference Watershed Approach.” Meeting the water quality objectives specified by these TMDLs will result in the impaired stream segments attaining their designated uses.

The Reference Watershed Approach compares two watersheds, one attaining its uses and one that is impaired based on biological assessments. Both watersheds must have similar land use/cover distributions. Other features such as base geologic formation should be matched to the extent possible; however, most variations can be adjusted in the modeling process. The objective of this approach is to reduce the loading rate of pollutants in the impaired stream segment to a level equivalent to, or slightly lower than, the loading rate in the non-impaired, reference segment. This load reduction will result in conditions favorable to the return of a healthy biological community to the impaired stream segments.

D. Selection of the Reference Watershed

In general, three factors are considered when selecting a suitable reference watershed. The first factor is to use a watershed that the PA DEP has assessed and determined to be attaining water quality standards. The second factor is to find a watershed that closely resembles the impaired watershed in physical properties such as land cover/land use, physiographic province, and geology. Finally, the difference in the size between the reference watershed and the impaired watershed should not be greater than 20 to 30 percent. The search for a reference watershed for Plum Run that would satisfy the above characteristics was done by means of a desktop screening using several GIS (geographical information systems) coverages, including the Multi-Resolution Land Characteristics (MRLC), Landsat-derived land use/cover grid, geologic rock types, and Pennsylvania’s 305(b) assessed streams database. Descriptions of the land use/covers are given in Appendix H.

A tributary to Big Run, in Lawrence County, was selected as the reference watershed for the Plum Run TMDL (Figure 1). This watershed is part of the Shenango River watershed, north of the Chartiers Creek watershed. It is located in State Water Plan 20B. The watershed has protected uses of aquatic life, water supply, and recreation. The reference portion of the Big Run is currently designated as Warm Water Fishes (WWF) under §93.9f in Title 25 of the Pa. Code (Commonwealth of Pennsylvania, 2001).

A survey, conducted in August 1999 by the Northwest Regional office of DEP, concluded that the tributary to Big Run was attaining its designated uses. Except for low flow of water in the channel, due to the summer conditions, the habitat assessment was excellent. Sixteen taxa of aquatic macroinvertebrates were recovered at the station, including mayflies and caddisflies.

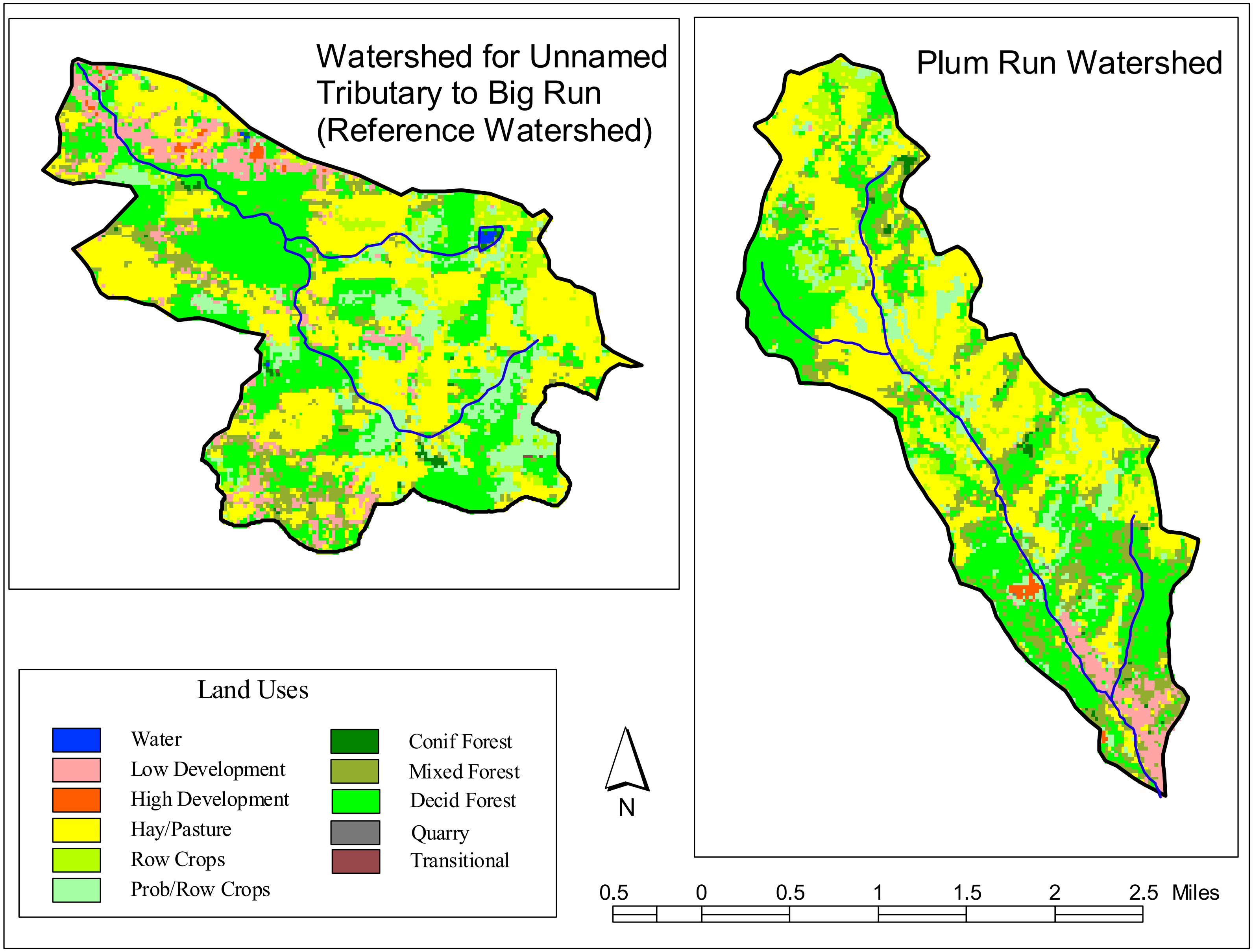
Drainage area, location, and other physical characteristics of the Plum Run watershed were compared to the reference watershed (Table 4). An analysis of land use revealed that while land cover/use distributions are not an exact match, both watersheds are similar. Agriculture, including cropland and pasture, and forest are the dominant land use categories in both watersheds (Figure 3). In the Big Run watershed, some of the land (formally farm land) is being subdivided for housing developments. Most farms are still operating, but small. Most of the cattle and horses are fenced from the stream or there is a large riparian buffer zone to keep them from the stream. There are some cornfields, but they are not in the riparian zone or in the immediate floodplain.

Surficial geology in the Plum Run and reference watersheds were also compared. Rock types in the Plum Run watershed include interbedded sedimentary and sandstone. The reference watershed also has interbedded sedimentary and sandstone rock types. Bedrock geology primarily affects surface runoff and background nutrient loads through its influences on soils, landscape, fracture density, and directional permeability. Plum Run and the reference watershed are very similar in terms of soil types, precipitation, and average runoff (Table 4).

Specific geology of Plum Run was given in Section I. C. The geology of the reference watershed consists mainly of the Allegheny Formation. This formation consists mainly of sandstone along with shale, and some limestone, clay, and coal. The Pottsville Formation is located in a limited area around the base of the tributary. This formation consists of sandstone, conglomerate, shale, siltstone, claystone, limestone, and coal.

Table 4 - Comparison Between Plum Run and the Reference Watershed		
	WATERSHED	
ATTRIBUTE	**Plum Run Watershed**	**Reference Watershed**
Physiographic Province	Appalachian Plateaus Province (Waynesburg Hills Section)	Appalachian Plateaus Province (Northwestern Glaciated Plateau Section)
Area (mi^2)	4.06	4.76
Land Use	Forest (45%) Pasture/Hay (34%) Cropland (17%) Low Intensity Development (4%) High Intensity Development (0.2%) Quarry (0.1%)	Forest (40%) Pasture/Hay (35%) Cropland (17%) Low Intensity Development (8%) High Intensity Development (0.2%) Transitional (0.1%)
Geology	Interbedded Sedimentary (%) Sandstone (%)	Interbedded Sedimentary (98%) Sandstone (2%)
Soils	Gilpin-Dormont-Culleoka (94%) Dormont-Culleoka-Guernsey (2%)	Ravenna-Canfield-Frenchtown (100%)
Dominant HSG	C	C
23-Year Average Rainfall (in)	37.4	40.1
23-Year Average Runoff (in)	1.45	2.02

Figure 3 - Land Uses in Plum Run Watershed and the Reference Watershed



III. Watershed Assessment and Modeling

TMDLs for the Plum Run watershed were developed using the ArcView Generalized Watershed Loading Function (AVGWLF) model. Appendix B provides and overview of the AVGWLF model, including a description of the Revised Universal Soil Loss Equation, and the GIS-based derivation of input data. The AVGWLF model was calibrated for the state of Pennsylvania using data from representative watersheds throughout the state. The reader is referred to AVGWLF for further details of the application of the model.

The AVGWLF model was used to establish existing loading conditions for the Plum Run watershed and the reference watershed. The Pittsburgh weather station was used in the model. PA DEP staff visited both watersheds in November 2002. These field visits were conducted to get a better understanding of existing conditions that might influence the AVGWLF model. Minor adjustments were made to specific parameters used in the AVGWLF model based on observations made while touring the watershed.

Figures 4 to 8 illustrate some of the water quality issues in the Plum Run and reference watersheds. Figure 4 shows cattle with free access to Plum Run. This access can create increased sedimentation from stream bank erosion. In addition, the lack of the stream corridor can also increase the amount of nutrients. The lack of cover crops on sloped croplands, as seen in Figure 5, can increase the amount of solids and nutrients in the runoff. Figure 6 shows Plum Run flowing through residential areas. The lack of a stream buffer can result in increased nutrients (from fertilizer) and stream bank erosion. Figure 7 illustrates the livestock buffer zones around stream in the reference Watershed. The conversion of cropland to development in the reference watershed is shown in Figure 8.

The AVGWLF model produced information on watershed size, land use, sediment loading, and total phosphorus loading (Tables 5 and 6). Modeling outputs have been attached to this TMDL as Appendices C and D. The sediment and total phosphorus loads represent an annual average over the 23-year period simulated by the model (April 1975 to March 1998). This information was then used to calculate existing unit area loading rates for the Plum Run and reference watersheds. There are different loading rates associated with each land use as a result of the different practices occurring on these lands.

Unit area loading rates for sediment and total phosphorus were estimated for each watershed by dividing the mean annual loadings (lbs/yr) by the total area (acres). Unit area load estimates for sediment and total phosphorus in the Plum Run watershed are 68.64 lbs/ac/yr and 0.15 lbs/ac/yr, respectively)(Table 5). Unit area load estimates for sediment and total phosphorus in the reference watershed are 35.44 lbs/ac/yr and 0.12 lbs/ac/yr, respectively (Table 6).

Figure 4 - Example of Livestock in Plum Run Watershed

Figure 5 - Example of Sloped Cropland in Plum Run Watershed

Figure 6 - Plum Run Flowing Through Low Density Development Area

Figure 7 - Example of Livestock Buffer Zone Along Unnamed Tributary to Big Run

Figure 8 - New Housing in the Reference Watershed

Table 5 - Existing Sediment and Total Phosphorus Loads for the Plum Run Watershed					
		Sediment		Total Phosphorus	
Pollutant Source	**Area (ac)**	**Mean Annual Loading (lbs/yr)**	**Unit Area Loading (lbs/ac/yr)**	**Mean Annual Loading (lbs/yr)**	**Unit Area Loading (lbs/ac/yr)**
Hay/Pasture	892.0	38,020	42.62	61.6	0.07
Cropland	430.0	131,680	306.23	110.2	0.26
Conifer Forest	24.7	20	0.81	0.1	0.00
Mixed Forest	348.4	640	1.84	0.9	0.00
Deciduous Forest	790.7	2,740	3.47	2.6	0.00
Quarry	2.5	1,660	664.00	0.9	0.37
Low Intensity Development	106.3	20	0.19	0.2	0.00
High Intensity Development	4.9	0	0.00	0.0	0.00
Stream bank	--	3,640	--	1.0	--
Groundwater	--	--	--	197.0	--
Point Sources	--	--	--	0.0	--
Septic Systems	--	--	--	7.5	--
Total	**2,599.5**	**178,420**	**68.64**	**382.0**	**0.15**

Table 6 - Existing Sediment and Total Phosphorus Loads for the Reference Watershed					
		Sediment		Total Phosphorus	
Pollutant Source	Area (ac)	Mean Annual Loading (lbs/yr)	Unit Area Loading (lbs/ac/yr)	Mean Annual Loading (lbs/yr)	Unit Area Loading (lbs/ac/yr)
Hay/Pasture	1,072.4	19,920	18.58	72.0	0.07
Cropland	511.5	79,300	155.03	93.5	0.18
Conifer Forest	24.7	0	0.00	0.1	0.00
Mixed Forest	212.5	160	0.75	0.5	0.00
Deciduous Forest	966.2	1,080	1.12	2.3	0.00
Transitional	2.5	600	240.00	0.9	0.35
Low Intensity Development	249.6	20	0.08	0.6	0.00
High Intensity Development	7.4	0	0.00	0.0	0.00
Stream bank	--	6,900	--	1.5	--
Groundwater	--	--	--	189.0	--
Point Sources	--	--	--	0.0	--
Septic Systems	--	--	--	5.6	--
Total	**3,046.8**	**107,980**	**35.44**	**366.0**	**0.12**

IV. TMDLs

Targeted TMDL values for the Plum Run watershed were established based on current loading rates for sediment and total phosphorus in the reference watershed. The entire lengths of both Plum Run and the unnamed tributary to Big Run are currently designated as Warm Water Fishes—maintenance and propagation of fish species and additional flora and fauna, which are indigenous to a warm water habitat. Recent assessments have determined that the unnamed tributary to Big Run is attaining its designated uses. Reducing the loading rates of sediment and total phosphorus in the Plum Run basin to levels equal to, or less than, the reference watershed will provide conditions favorable for the reversal of current use impairments.

A. Background Pollutant Conditions

There are two separate considerations of background pollutants within the context of these TMDLs. First, the reference watershed approach inherently assumes that, because of the similarities between the reference and impaired watershed, the background pollutant contributions of both will be similar. Therefore, the background pollutant contributions will be considered when determining the loads for the impaired watershed that are consistent with the loads from the reference watershed. Second, the AVGWLF model implicitly considers background pollutant contributions through the soil and the groundwater component of the model process.

B. Targeted TMDL

Targeted TMDL values for sediment and total phosphorus were determined by multiplying the total area of the Plum Run watershed by the appropriate unit area loading rates for the reference watershed (Table 7).

Table 7 - Targeted TMDLs for the Plum Run Watershed			
Pollutant	Area (ac)	Unit Area Loading Rate Big Run Ref. Watershed (lbs/ac/yr)	Targeted TMDL (lbs/yr)
Sediment	2,599.5	35.44	92,127
Total P	2,599.5	0.12	312.2

Targeted TMDL values were used as the basis for load allocations and reductions in the Plum Run watershed, using the following two equations:

1. TMDL = 3WLA + 3LA + MOS
2. LA = ALA + LNR

where:

TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation (point sources)
LA = Load Allocation (nonpoint sources)
ALA = Adjusted Load Allocation
LNR = Loads not Reduced

C. Wasteload Allocation

The waste load allocation (WLA) portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. Review of the PA DEP's permitting files identified no point sources of sediment or nutrients in the Plum Run watershed. Therefore, the WLA was set at zero.

D. Margin of Safety

The margin of safety (MOS) is that portion of the pollutant loading that is reserved to account for any uncertainty in the data and computational methodology used for the analysis. For this analysis, the MOS is explicit. Ten percent of the targeted TMDLs for sediment and total phosphorus were reserved as the MOS. Using 10 percent of the TMDL load is based on professional judgment and will provide an additional level of protection to the designated uses of Plum Run. The MOS for the sediment TMDL and the MOS for the total phosphorus TMDL were set at 9,213 lbs/yr and 31.2 lbs/yr, respectively.

MOS (Sediment) = 92,127 lbs/yr (TMDL) x 0.1 = 9,213 lbs/yr
MOS (Phosphorus) = 312.2 lbs/yr (TMDL) x 0.1 = 31.2 lbs/yr

E. Load Allocation

The load allocation (LA) is that portion of the TMDL that is assigned to nonpoint sources. Since there are no point sources present in the Plum Run watershed, load allocations for sediment and phosphorus were computed by subtracting the MOS value from the targeted TMDL value. Load allocations for sediment and phosphorus were 82,915 lbs/yr and 281.0 lbs/yr, respectively.

LA (Sediment) = 92,127 lbs/yr (TMDL) – 9,213 lbs/yr (MOS) = 82,915 lbs/yr
LA (Phosphorus) = 312.2 lbs/yr (TMDL) – 31.2 lbs/yr (MOS) = 281.0 lbs/yr

F. Adjusted Load Allocation

The adjusted load allocation (ALA) is the actual portion of the LA distributed among those nonpoint sources receiving reductions. It is computed by subtracting those nonpoint source loads that are not being considered for reductions (loads not reduced or LNR) from the LA. Since the Plum Run watershed TMDLs were developed to address impairments resulting from agricultural activities, only agriculture related sources were considered for reductions. Reductions were applied to hay/pasture and cropland for both sediment and total phosphorus. Those land uses/sources for which existing loads were not reduced (conifer forest, mixed forest, deciduous forest, quarry, low intensity development, high intensity development, stream bank, groundwater, point source, and septic systems) were carried through at their existing loading values (Table 8). The ALA for sediment and phosphorus were 74,195 lbs/yr and 70.8 lbs/yr, respectively.

Table 8 - Load Allocations, Loads Not Reduced, and Adjusted Load Allocations for Plum Run TMDLs

	Sediment (lbs/yr)	Total P (lbs/yr)
Load Allocation	82,915	281.0
Loads Not Reduced	8,720	210.2
Conifer Forest	20	0.1
Mixed Forest	640	0.9
Deciduous Forest	2,740	2.7
Quarry	1,660	0.9
Low Intensity Development	20	0.2
High Intensity Development	0	0.0
Stream bank	3,640	1.0
Groundwater	--	197.0
Point Sources	--	0.0
Septic Systems	--	7.5
Adjusted Load Allocation	74,195	70.8

G. TMDLs

Both the sediment and total phosphorus TMDLs established for the Plum Run watershed consist of a Load Allocation (LA) and a Margin of Safety (MOS). No TMDL was established for nitrogen because the stream is phosphorus-limited. The individual components of the TMDLs are summarized in Table 9.

Table 9 - TMDL, WLA, MOS, LA, LNR, and ALA for Plum Run Watershed

Component	Sediment (lbs/yr)	Total Phosphorus (lbs/yr)
TMDL (Total Maximum Daily Load)	92,127	312.2
WLA (Wasteload Allocation)	0	0.0
MOS (Margin of Safety)	9,213	31.2
LA (Load Allocation)	82,915	281.0
LNR (Loads Not Reduced)	8,720	210.2
ALA (Adjusted Load Allocation)	74,195	70.8

V. Calculation of Sediment and Nutrient Load Reductions

Adjusted load allocations established in the previous section represent the sediment and total phosphorus loads that are available for allocation between contributing sources in the Plum Run watershed. Data needed for load reduction analyses, including land use distribution, were obtained by GIS analysis. The Equal Marginal Percent Reduction (EMPR) allocation method (Appendix E) was used to distribute the ALA between the appropriate contributing land uses.

The load allocation and EMPR procedures were performed using Microsoft Excel and results are presented in Appendix F. Table 10 contains the results of the EMPR for sediment and total phosphorus for the appropriate contributing land uses in Plum Run watershed. The load allocation for each land use is shown, along with the percent reduction of current loads necessary to reach the targeted LA.

Table 10 - Sediment and Phosphorus Load Allocations & Reductions for the Plum Run Watershed						
Sediment						
Pollutant Source	**Acres**	**Unit Area Loading Rate (lbs/ac/yr)**		**Pollutant Loading (lbs/yr)**		**Percent Reduction**
		Current	**Allowable**	**Current**	**Allowable (LA)**	
Hay and Pasture	892.0	42.6	28.2	38,020	25,138	34%
Cropland	430.0	306.2	114.1	131,680	49,056	63%
NPS Loads Not Reduced	-	-	-	8,720	8,720	
Total				178,420	82,915	54%
Total Phosphorus						
Pollutant Source	**Acres**	**Unit Area Loading Rate (lbs/ac/yr)**		**Pollutant Loading (lbs/yr)**		**Percent Reduction**
		Current	**Allowable**	**Current**	**Allowable (LA)**	
Hay and Pasture	892.0	0.069	0.037	61.6	32.9	47%
Cropland	430.0	0.256	0.088	110.2	37.9	66%
NPS Loads Not Reduced	-	-	-	210.2	210.2	
Total				382.0	281.0	26%

VI. Consideration of Critical Conditions

The AVGWLF model is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Therefore, all flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of sediment and nutrients to a waterbody and the resulting impact on designated uses, establishing these TMDLs using average annual conditions is protective of the waterbody.

VII. Consideration of Seasonal Variations

The continuous simulation model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model requires specification of the growing season and hours of daylight for each month. The model also considers the months of the year when manure is applied to the land. The combination of these actions by the model accounts for seasonal variability.

VIII. Recommendations

TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Plum Run TMDLs identify the necessary overall load reductions for those pollutants currently causing use impairments and distribute those reduction goals to the appropriate nonpoint sources. Reaching the reduction goals established by these TMDLs will only occur through changes in current land use practices, including the incorporation of more agricultural best management practices (BMPs). BMPs that would be helpful in lowering the amount of sediment and nutrients reaching Plum Run include stream bank fencing, riparian buffer strips, strip cropping, contour plowing, conservation crop rotation, and heavy use area protection, among many others.

The Natural Resources Conservation Service maintains a National Handbook of Conservation Practices (NHCP), which provides information on a variety of BMPs. The NHCP is available online at http://www.ncg.nrcs.usda.gov/nhcp_2.html. Many of the practices described in the handbook could be used on agricultural lands in the Plum Run watershed to help limit siltation and nutrient impairments. Determining the most appropriate BMPs, where they should be installed, and actually putting them into practice, will require the development and implementation of a comprehensive watershed restoration plan. Development of any restoration plan will involve the gathering of site-specific information regarding current land uses and existing conservation practices. The required level of detail is outside the scope of this TMDL document and is an activity best accomplished at the local level. Successful implementation of the activities necessary to address current use impairments to Plum Run will require local citizens taking an active interest in the watershed and the enthusiastic cooperation of local landowners.

By developing TMDLs for the Plum Run watershed, the PA DEP has set the stage for local citizens to design and implement restoration plans to correct current use impairments. The PA DEP will support local efforts to develop and implement watershed restoration plans based on the reduction goals specified in the TMDLs. Interested parties should contact the appropriate Watershed Manager in the PA DEP's Southwest Regional Office (412-442-4000) for information regarding technical and financial assistance currently available. Individuals and/or local watershed groups interested in "fixing" the identified problems in the Plum Run watershed are strongly encouraged to avail themselves of funding sources available through the PA DEP and other state and federal agencies (e.g., Growing Greener or 319 Program).

IX. Public Participation

A notice of availability for comments on the draft Plum Run watershed TMDLs was published in the PA Bulletin on December 14, 2002 and on the PA DEP's web page on December 14, 2002. In addition, a public meeting was held on January 15, 2003 at the Chartiers Valley High School, Bridgeville, PA to address any outstanding concerns regarding the draft TMDLs. A 60-day period (ending on February 15, 2003) was provided for the submittal of comments. Comments and responses are summarized in Appendix G.

Notice of final TMDL approvals will be posted on the PA DEP's website.

Literature Cited

Commonwealth of Pennsylvania. 2001. Pennsylvania Code. Title 25 Environmental Protection. Department of Environmental Protection. Chapter 93. Water Quality Standards. Harrisburg, PA.

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Novotny, V. and H. Olem, 1994. Water Quality: Prevention, Identification, and Management of Diffuse Pollution. Van Nostrand Reinhold, New York.

Thomann, R.V. and J.A. Mueller, 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, New York.

Appendix A - Information Sheet for Plum Run Watershed TMDLs

What is being proposed?
Total Maximum Daily Load (TMDL) plans have been developed to improve water quality in the Plum Run watershed.

Who is proposing the plans? Why?
The Pennsylvania Department of Environmental Protection (PA DEP) is proposing to submit the plans to the U.S. Environmental Protection Agency (U.S. EPA) for review and approval as required by federal regulation. In 1995, U.S. EPA was sued for not developing TMDLs when Pennsylvania failed to do so. PA DEP has entered into an agreement with U.S. EPA to develop TMDLs for certain specified waters over the next several years. These TMDLs have been developed in compliance with the state/U.S. EPA agreement.

What is a TMDL?
A TMDL sets a ceiling on the pollutant loads that can enter a waterbody so that it will meet water quality standards. The Clean Water Act requires states to list all waters that do not meet their water quality standards even after pollution controls required by law are in place. For these waters, the state must calculate how much of a substance can be put in the water without violating the standard, and then distribute that quantity to all sources of the pollutant on that water body. A TMDL plan includes waste load allocations for point sources, load allocations for nonpoint sources, and a margin of safety. The Clean Water Act requires states to submit their TMDLs to U.S. EPA for approval. Also, if a state does not develop the TMDL, the Clean Water Act states that U.S. EPA must do so.

What is a water quality standard?
The Clean Water Act sets a national minimum goal that all waters are to be “fishable” and “swimmable.” To support this goal, states must adopt water quality standards. Water quality standards are state regulations that have two components. The first component is a designated use, such as “warm water fishes” or “recreation.” States must assign a use, or several uses to each of their waters. The second component relates to the instream conditions necessary to protect the designated use(s). These conditions or “criteria” are physical, chemical, or biological characteristics such as temperature and minimum levels of dissolved oxygen, and maximum concentrations of toxic pollutants. It is the combination of the “designated use” and the “criteria” to support that use that make up a water quality standard. If any criteria are being exceeded, then the use is not being meet and the water is said to be in violation of water quality standards.

What is the purpose of the plans?
Plum Run is impaired by excess suspended solids and nutrients. These TMDL plans include a calculation of sediment and total phosphorus loadings that will meet water quality objectives.

Why was the Plum Run watershed selected for TMDL development?
In 1996, PA DEP listed a portion of the Plum Run watershed under Section 303(d) of the federal Clean Water Act as impaired due to excess nutrients and suspended solids. In 1998, the entire watershed was listed as impaired due to a combination of nutrients and suspended solids impairments. The tributaries are listed for nutrients, siltation, organic enrichment/low dissolved oxygen, and other habitat modifications.

What pollutants do these TMDLs address?
The proposed plans provide calculations of the stream’s total capacity to accept sediment and phosphorus. Based on an evaluation of the concentrations of nutrients in Plum Run, phosphorus is the cause of nutrient impairment to the stream. Sediment loading is being used to address suspended solids, siltation, and turbidity impairments.

Where do the pollutants come from?
The sediment and nutrient related impairments in the Plum Run watershed come from nonpoint sources (NPS) of pollution, primarily overland runoff from agricultural land uses. In the tributaries, habitat modification and on-site wastewater systems also contribute to the NPS pollution.

How was the TMDL developed?
PA DEP used a reference watershed approach to estimate the necessary loading reduction of sediment and phosphorus that would be needed to restore a healthy aquatic community. The reference watershed approach is based on selecting a non-impaired watershed that has similar land use characteristics and determining the current loading rates for the pollutants of interest. This is done by modeling the loads that enter the stream, using precipitation and land use characteristic data. For this analysis, PA DEP used the AVGWLF model (the Environmental Resources Research Institute of the Pennsylvania State University's ArcView based version of the Generalized Watershed Loading Function model developed by Cornell University). This modeling process uses loading rates in the non-impaired watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current loading rates and determine what reductions are necessary to meet the loading rates of the non-impaired watershed. The reference stream approach was used to set allowable loading rates in the affected watershed because neither Pennsylvanian nor U.S. EPA has water quality criteria for sediment or phosphorus.

How much pollution is too much?
The allowable amount of pollution in a water body varies depending on several conditions. TMDLs are set to meet water quality standards at the critical flow condition. For a free flowing stream impacted by nonpoint source pollution loading of sediment and nutrients, the TMDL is expressed as an annual loading. This accounts for pollution contributions over all stream flow conditions. PA DEP established the water quality objectives for sediment and phosphorus by using the reference watershed approach. This approach assumes that the impairment is eliminated when the impaired watershed achieves loadings similar to the reference watershed. Reducing the current loading rates for sediment and phosphorus in the impaired watershed to the current loading rates in the reference watershed will result in meeting the water quality objectives.

How will the loading limits be met?
Best Management Practices (BMPs) will be encouraged throughout the watershed to achieve the necessary load reductions.

How can I get more information on the TMDL?
To request a copy of the full report, contact Carol Young at 717-783-2952 during the business hours of 8:00 a.m. to 3:00 p.m., Monday through Friday. You may also contact Ms. Young by mail at the TMDL and Modeling Section, Division of Water Quality Assessment and Standards, PA DEP, 400 Market Street, Harrisburg, PA 17105 or by e-mail at cayoung@state.pa.us.

How can I comment on the proposal?
You may provide e-mail or written comments postmarked no later than February 12, 2003 to the above address.

Appendix B - AVGWLF Model Overview & GIS-Based Derivation of Input Data

TMDLs for the Plum Run watershed were developed using the Generalized Watershed Loading Function or GWLF model. The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model, which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

GWLF is a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the Universal Soil Loss Equation (USLE) algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss erosion (K), the length slope factor (LS) the vegetation cover factor (C) and conservation practices factor (P). A sediment delivery ratio based on watershed size and transport capacities based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges can also contribute to dissolved losses to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Sub-surface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads, and the sub-surface sub-model only considers a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be viewed in GWLF Users Manuel, available from PA DEP's Bureau of Watershed Conservation, Division of Assessment and Standards.

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather

(WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

The primary sources of data for this analysis were GIS formatted databases. A specially designed interface was prepared by the Environmental Resources Research Institute of the Pennsylvania State University in ArcView (GIS software) to generate the data needed to run the GWLF model, which was developed by Cornell University. The new version of this model has been named AVGWLF (ArcView Version of the Generalized Watershed Loading Function).

In using the AVGWLF, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land and the names of nearby weather stations). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the TRANSPRT.DAT, NUTRIENT.DAT and WEATHER.DAT input files needed to execute the GWLF model. For use in Pennsylvania, AVGWLF has been linked with statewide GIS data layers such as land use/cover, soils, topography, and physiography; and includes location-specific default information such as background N and P concentrations and cropping practices.

The AVGWLF model was calibrated to 16 watersheds throughout Pennsylvania and verified on an additional 16 watersheds. The Chartiers watershed was used as a verification watershed. A statistical evaluation of the accuracy of the load predictions was made. Nash-Sutcliffe coefficients of correlation derived for the calibration and verification watersheds ranged in value from 0.92 to 0.97 for both nitrogen and phosphorus when considering mean annual loads. The median N-S values for nitrogen varied between 0.64 to 0.70 for monthly, seasonal, and year-to-year load estimates; and for phosphorus they varied between 0.61 and 0.72.

Complete GWLF-formatted weather files are also included for eighty weather stations around the state. The following table lists the statewide GIS data sets and provides an explanation of how they were used for development of the input files for the GWLF model.

The reader is referred to the *AVGWLF User's Guide* for further details.

GIS Data Sets	
DATASET	DESCRIPTION
Censustr	Coverage of Census data including information on individual homes septic systems. The attribute *usew_sept* includes data on conventional systems, and *sew_other* provides data on short-circuiting and other systems.
County	The County boundaries coverage lists data on conservation practices, which provides C and P values in the Universal Soil Loss Equation (USLE).
Gwnback	A grid of background concentrations of N in groundwater derived from water well sampling.
Landuse5	Grid of the MRLC that has been reclassified into five categories. This is used primarily as a background.
Majored	Coverage of major roads. Used for reconnaissance of a watershed.
MCD	Minor civil divisions (boroughs, townships and cities).
Npdespts	A coverage of permitted point discharges. Provides background information and cross check for the point source coverage.
Padem	100-meter digital elevation model. This used to calculate landslope and slope length.
Palumrlc	A satellite image derived land cover grid that is classified into 15 different landcover categories. This dataset provides landcover loading rate for the different categories in the model.
Pasingle	The 1:24,000 scale single line stream coverage of Pennsylvania. Provides a complete network of streams with coded stream segments.
Physprov	A shapefile of physiographic provinces. Attributes *rain_cool* and *rain_warm* are used to set recession coefficient
Pointsrc	Major point source discharges with permitted N and P loads.
Refwater	Shapefile of reference watersheds for which nutrient and sediment loads have been calculated.
Soilphos	A grid of soil phosphorous loads, which has been generated from soil sample data. Used to help set phosphorus and sediment values.
Smallsheds	A coverage of watersheds derived at 1:24,000 scale. This coverage is used with the stream network to delineate the desired level watershed.
Statsgo	A shapefile of generalized soil boundaries. The attribute *mu_k* sets the k factor in the USLE. The attribute *mu_awc* is the unsaturated available capacity., and the *muhsg_dom* is used with landuse cover to derive curve numbers.
Strm305	A coverage of stream water quality as reported in the Pennsylvania's 305(b) report. Current status of assessed streams.
Surfgeol	A shapefile of the surface geology used to compare watersheds of similar qualities.
T9sheds	Data derived from a DEP study conducted at PSU with N and P loads.
Zipcode	A coverage of animal densities. Attribute *aeu_acre* helps estimate N & P concentrations in runoff in agricultural lands and over manured areas.
Weather Files	Historical weather files for stations around Pennsylvania to simulate flow.

Appendix C - AVGWLF Model Outputs for the Plum Run Watershed

GWLF Transport Summary for Plum_Run_shed

Period of analysis: 23 years, from Apr 1975 to Mar 1998

	Units in Inches				
Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	2.90	1.18	2.10	0.09	2.19
MAY	3.79	2.79	1.52	0.04	1.55
JUN	3.77	4.65	0.68	0.04	0.72
JUL	3.92	5.17	0.20	0.09	0.29
AUG	3.68	3.69	0.02	0.09	0.11
SEP	3.06	2.43	0.04	0.03	0.07
OCT	2.42	1.36	0.16	0.04	0.20
NOV	3.13	0.64	0.42	0.18	0.60
DEC	2.74	0.26	1.43	0.16	1.60
JAN	2.51	0.13	1.74	0.23	1.97
FEB	2.27	0.21	1.93	0.27	2.20
MAR	3.25	0.66	2.55	0.18	2.73
Total	37.43	23.17	12.80	1.45	14.24

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GWLF Nutrient Summary for Plum_Run_shed

Period of analysis: 23 years, from Apr 1975 to Mar 1998

	Tons		Nutrient Loads (Pounds)			
Month	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos
APR	46.19	8.50	2221.99	2231.31	36.24	37.95
MAY	65.54	12.06	1653.35	1658.66	26.70	27.67
JUN	68.50	12.60	822.38	845.19	14.21	18.40
JUL	105.64	19.44	475.52	508.37	10.38	16.40
AUG	77.57	14.27	83.33	127.32	4.03	12.11
SEP	17.34	3.19	64.71	69.73	2.35	3.27
OCT	12.99	2.39	194.92	211.51	4.67	7.72
NOV	23.39	4.30	544.61	605.62	13.46	24.68
DEC	16.26	2.99	1915.73	1981.47	33.99	46.08
JAN	9.19	1.69	2398.89	2466.34	42.95	55.36
FEB	12.84	2.36	2734.36	2871.08	49.03	74.19
MAR	19.41	3.57	2760.19	2824.33	46.36	58.16
Total	474.87	87.38	15869.97	16400.92	284.37	382.00

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GWLF Total Loads for Plum_Run_shed

Period of analysis: 23 years, from Apr 1975 to Mar 1998

Source	(Acres) Area	(in) Runoff	(Tons) Erosion	(Tons) Sediment	Total Loads (Pounds) Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	892.0	1.27	103.31	19.01	1412.17	1526.23	40.59	61.57
CROPLAND	430.0	2.46	357.81	65.84	1298.72	1693.75	37.56	110.24
CONIF_FOR	24.7	1.05	0.05	0.01	1.12	1.18	0.04	0.05
MIXED_FOR	348.4	1.05	1.74	0.32	15.81	17.73	0.50	0.85
DECID_FOR	790.7	1.05	7.45	1.37	35.87	44.10	1.13	2.65
QUARRY	2.5	5.10	4.50	0.83	0.03	5.01	0.01	0.92
LO_INT_DEV	106.3	2.71	0.08	0.01	0.00	1.22	0.00	0.16
HI_INT_DEV	4.9	8.45	0.00	0.00	0.00	0.03	0.00	0.00
Stream Bank				1.82		5.45		1.00
Groundwater					11327.17	11327.17	197.04	197.04
Point Sources					0.00	0.00	0.00	0.00
Septic Syst.					1779.07	1779.07	7.51	7.51
Totals	2599.5	1.40	475.0	89.2	15869.97	16400.92	284.37	382.00

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Appendix D - AVGWLF Model Outputs for the Big Run Reference Watershed

GWLF Transport Summary for Big_Run_Shed

Period of analysis: 23 years, from Apr 1975 to Mar 1998

Units in Inches

Month	Precip	Evapotrans	Gr. Wat. Flow	Runoff	Streamflow
APR	3.08	0.94	2.39	0.10	2.49
MAY	3.67	2.40	1.64	0.03	1.68
JUN	4.56	4.11	1.25	0.10	1.35
JUL	4.48	5.20	0.57	0.14	0.71
AUG	3.73	4.24	0.32	0.07	0.39
SEP	3.91	2.58	0.19	0.10	0.29
OCT	2.80	1.23	0.52	0.09	0.61
NOV	3.47	0.53	1.22	0.20	1.41
DEC	2.84	0.18	1.97	0.19	2.16
JAN	2.38	0.07	1.57	0.23	1.80
FEB	2.04	0.14	1.70	0.40	2.10
MAR	3.14	0.46	2.58	0.37	2.95
Total	40.11	22.08	15.93	2.02	17.94

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GWLF Nutrient Summary for Big_Run_Shed

Period of analysis: 23 years, from Apr 1975 to Mar 1998

	Tons		Nutrient Loads (Pounds)			
Month	**Erosion**	**Sediment**	**Dis. Nitr.**	**Tot. Nitr.**	**Dis. Phos.**	**Tot. Phos**
APR	31.55	5.71	715.15	721.14	32.90	33.79
MAY	22.38	4.05	531.97	534.13	22.71	23.03
JUN	55.84	10.11	637.44	646.05	23.31	24.58
JUL	62.19	11.26	584.29	603.98	18.17	21.08
AUG	50.43	9.13	131.53	146.57	7.24	9.46
SEP	17.86	3.23	128.31	147.27	6.84	9.66
OCT	7.86	1.42	192.33	201.48	10.39	11.75
NOV	10.42	1.89	436.64	455.33	22.87	25.64
DEC	6.48	1.17	1098.28	1128.39	38.95	43.42
JAN	2.88	0.52	1135.18	1180.98	37.33	44.14
FEB	2.54	0.46	1729.49	1801.01	52.04	62.67
MAR	8.76	1.59	1001.59	1073.91	45.97	56.72
Total	279.19	50.53	8322.19	8640.23	318.73	365.95

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GWLF Total Loads for Big_Run_Shed

Period of analysis: 23 years, from Apr 1975 to Mar 1998

	(Acres)	(in)	(Tons)		Total Loads (Pounds)			
Source	Area	Runoff	Erosion	Sediment	Dis. Nitr.	Tot. Nitr.	Dis. Phos.	Tot. Phos.
HAY/PAST	1072.4	1.68	55.03	9.96	2152.66	2212.42	63.08	71.97
CROPLAND	511.5	3.27	219.07	39.65	1973.74	2211.65	58.13	93.50
CONIF_FOR	24.7	1.39	0.02	0.00	1.48	1.51	0.05	0.05
MIXED_FOR	212.5	1.39	0.43	0.08	12.74	13.21	0.40	0.47
DECID_FOR	966.2	1.39	2.97	0.54	57.90	61.12	1.83	2.31
TRANSITION	2.5	5.39	1.66	0.30	8.75	10.56	0.60	0.87
LO_INT_DEV	249.6	3.60	0.08	0.01	0.00	4.47	0.00	0.60
HI_INT_DEV	7.4	10.70	0.00	0.00	0.00	0.02	0.00	0.00
Stream Bank				3.45		10.35		1.54
Groundwater					876.11	876.11	189.01	189.01
Point Sources					0.00	0.00	0.00	0.00
Septic Syst.					3238.82	3238.82	5.63	5.63
Totals	3046.8	2.00	279.3	54.0	8322.19	8640.23	318.73	365.95

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Appendix E - Equal Marginal Percent Reduction Method

The Equal Marginal Percent Reduction (EMPR) allocation method was used to distribute Adjusted Load Allocations (ALAs) between the appropriate contributing nonpoint sources. The load allocation and EMPR procedures were performed using MS Excel and results are presented in Appendix F. The 5 major steps identified in the spreadsheet are summarized below:

Step 1: Calculation of the TMDL based on impaired watershed size and unit area loading rate of reference watershed.

Step 2: Calculation of Adjusted Load Allocation based on TMDL, Margin of Safety, and existing loads not reduced.

Step 3: Actual EMPR Process.

a. Each land use/source load is compared with the total ALA to determine if any contributor would exceed the ALA by itself. The evaluation is carried out as if each source is the only contributor to the pollutant load of the receiving waterbody. If the contributor exceeds the ALA, that contributor would be reduced to the ALA. If a contributor is less than the ALA, it is set at the existing load. This is the baseline portion of EMPR.

b. After any necessary reductions have been made in the baseline, the multiple analyses are run. The multiple analyses will sum all of the baseline loads and compare them to the ALA. If the ALA is exceeded, an equal percent reduction will be made to all contributors' baseline values. After any necessary reductions in the multiple analyses, the final reduction percentage for each contributor can be computed.

Step 4: Calculation of total loading rate of all sources receiving reductions.

Step 5: Summary of existing loads, final load allocations, and percent reduction for each pollutant source.

Appendix F - Equal Marginal Percent Reduction Calculations for Plum Run

Sediment

Step 1: *TMDL (lbs/yr)*
*= Ref. Loading Rate * Impaired Area*
92,127

Step 2: *Adjusted Load Allocation*
= (TMDL - WLA - MOS) - Uncontrollable Loads
74,195

Step 3:

Source	***Average Load (lbs/yr)***	***Load Sum (lbs/yr)***	***Check***	***Initial Adjustment***	***Recheck***	***Initial % Reduction***	***Load Reduction (lbs/yr)***	***Initial LA (lbs/yr)***	***Area (acres)***	***Allowable Loading Rate***	***% Reduction***
Hay / Pasture	38,020	169,700	good	38,020	ADJUST	34%	12,882	25,138	892	28	34%
Cropland	131,680		bad	74,195	38,020	66%	25,138	49,056	430	114	63%

Step 4: *Average Loading Rate for Agricultural Sources (lbs/acre/yr)* 56

Step 5:

Source	***Acres***	***Allowable Loading Rate***	***Final Load Allocation***	***Current Loading Rates***	***Current Load***	***% Reduction***
Hay / Pasture	892	28	25,138	43	38,020	34%
Cropland	430	114	49,056	306	131,680	63%

Total Phosphorus

Step 1: *TMDL (lbs/yr)*
*= Ref. Loading Rate * Impaired Area*
312.2

Step 2: *Adjusted Load Allocation (lbs/yr)*
= (TMDL - WLA - MOS) - Uncontrollable Loads
70.8

Step 3:

Source	***Average Load (lbs/yr)***	***Load Sum (lbs/yr)***	***Check***	***Initial Adjustment***	***Recheck***	***Initial % Reduction***	***Load Reduction (lbs/yr)***	***Initial LA (lbs/yr)***	***Area (acres)***	***Allowable Loading Rate***	***% Reduction***
Hay / Pasture	61.6	171.8	good	61.6	ADJUST	47%	28.6	32.9	892	0.037	47%
Cropland	110.2		bad	70.8	61.6	53%	32.9	37.9	430	0.088	66%

Step 4: *Average Loading Rate for Agricultural Sources (lbs/acre/yr)* 0.05

Step 5:

Source	***Acres***	***Allowable Loading Rate***	***Final Load Allocation***	***Current Loading Rates***	***Current Load***	***% Reduction***
Hay / Pasture	892	0.037	32.9	0.069	61.6	47%
Cropland	430	0.088	37.9	0.256	110.2	66%

Appendix G - Comment & Response Document
Plum Run Watershed TMDLs

There were no public comments to the Draft Plum Run TMDL.

The contractor incorporated comments received from USEPA Region III into the final document.

Appendix H - Land Use Descriptions
Plum Run Watershed TMDLs

The land use categories used in the modeling effort are the following:

- *Water:* All areas of open water or permanent ice/snow cover generally with less than 30% cover of vegetation/land cover.

- *Low Intensity Development:* These areas include a mixture of constructed materials and vegetative cover. Constructed materials account for 50 to 80 percent of the land cover, while vegetation may account for 20 to 50 percent of the cover. Low intensity residential areas most commonly include single-family housing units.

- *High Intensity Development:* These highly developed areas include apartment complexes , row houses, and other locations where people live in large numbers. Vegetation accounts for less than 20 percent of the total land cover. Constructed/building materials account for 80 to 100 percent of the land cover.

- *Quarries:* This land cover includes all quarry areas, including sand and gravel operations, where there are extractive mining activities with significant surface expression.

- *Transitional:* Transitional areas are those that are dynamically changing from one land cover to another, often because of land use activities. These areas are usually sparsely vegetated (less than 25 percent of cover) and examples include forest clearcuts; a transition phase between forest and agricultural land; the temporary clearing of vegetation; and land cover changes due to natural causes, such as fires or floods.

- *Deciduous Forest:* This land cover is dominated by trees. Seventy percent or more of the trees are deciduous (tree species that shed foliage in response to seasonal change).

- *Evergreen Forest:* This land cover is dominated by trees. Seventy percent or more of the trees are conifers or evergreens.

- *Mixed Forest:* This land cover is dominated by trees, where neither deciduous nor conifer/evergreen species represent more than 70 percent of the cover present.

- *Pasture/Hay:* This land use coverage includes areas of grasses, legumes, or grass-legume mixtures that are planted for livestock grazing or the production of seed or hay crops. This coverage may include other areas with high percentages of grasses and other herbaceous vegetation such as golf courses and parks.

- *Row Crops:* These areas are regularly tilled and planted, often on an annual or biennial basis with corn, cotton, sorghum, vegetables, or other crops.

- *Probable Row Crops:* This land use cover may sometimes be confused with other areas, such as grasslands that were not green during times of spring data acquisitions.